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SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Southern California Plug-in Electric Vehicle Readiness Plan

Chapters for Employers

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7 Planning for Workplace Charging

7.1 Introduction

Workplaces present a significant, and largely untapped, opportunity for PEV charging. After residences, they are the single most important environment for electric refueling. Vehicles are generally parked at workplaces for several hours every weekday, making it possible for them to completely recharge before the commute home. This is especially important for maximizing the electric miles driven by PHEVs, which use gasoline when their batteries are depleted. The ability to charge at work may also encourage PEV adoption by those for whom residential charging is cost-prohibitive or logistically difficult, particularly residents of multi-unit dwellings. Workplace charging thus represents the "missing link" between residential and publicly accessible charging.

Employers may see workplace charging as a way to recruit and retain employees, reduce the company's carbon footprint, or attain LEED green building certification, among other goals. Workplace charging can also be a relatively cost-effective amenity for employers to provide. The vehicles' lengthy stays in parking lots allow them to recharge using slower, lower-voltage, less expensive Level 1 charging from common, often available outlets. But the ability to charge several cars at once using multiple cords on Level 2 equipment would also make faster charging a potentially feasible option.

For these reasons, adopting policies and incentives to encourage workplace charging should be a high priority for regional and local planners. This chapter will help planners assess workplace charging opportunities across and within local jurisdictions. It will describe how planners can use their own employment metrics and the maps provided in the Southern California PEV Atlas that accompanies this document to prioritize cities and parcels for targeted workplace charging assistance. This chapter also presents a discussion of measures planners can take to reduce the cost to employers of providing charging. It concludes with a demonstration of how employers can recover PEV electricity costs from employees in a way that is cost-effective for both.

7.2 Assessing the workplace charging opportunity

To determine whether and how to prioritize workplace charging efforts, planners must first measure the potential demand for such charging. The questions planners should ask lead from the most general assessment of the overall size and location of workplaces to a more specific look at how they compare to other land uses within the jurisdiction. Cities can further target specific employers based on size and industry type. Additonally, white-collar employees, high-tech workplaces, and other characteristics may indicate PEV charging demand by employees.

The tools in this chapter will help councils of government (COGs) answer the following questions:

- How many employees are there in absolute numbers within each city?
- How many workplaces are there in absolute numbers within each city?
- How significant are workplaces compared to other types of parcels?

The tools in this chapter will help city planners and utilities answer the following questions:

- What are the largest employers and where are they located?
- Which employers have the highest numbers of white-collar and high-tech workers?
- Which employers are located in neighborhoods where current PEV owners drive on weekday mornings?

7.2.1 How many employees and workplaces are there in absolute numbers within each city?

Comparing the employee populations of cities will help a COG determine where its resources will be most effective in advancing workplace charging for the highest number of employees in the subregion. The UCLA Luskin Center obtained its figures from the Southern California Association of Governments' 2008 dataset from Infogroup, a vendor of employment information. The U.S. Census, Bureau of Labor Statistics and California Employment Development Department are other sources of employment information.

While absolute counts are a helpful indicator of the importance of a city's employees to advancing regional PEV readiness, these counts may not reflect the relative importance of workplace charging opportunities compared to residential charging within a city. They may also overlook areas that are rich in workplaces—places that may benefit from employer incentives and outreach.

While most PEV policies and incentives are geared towards drivers, workplaces represent an opportunity for targeted incentives. They can benefit from permit streamlining and PEV-ready building codes geared to non-residential uses. Jurisdictions rich in workplaces can also benefit from education and outreach programs targeted to employers. An example of a ranking of jurisdictions by number of employees and workplaces at the Los Angeles County level is

provided in Table 7.1.

Highlighted in red are cities that did not rank in the top counts of *employees* but that have a large number of *employers*. This may indicate the presence of more, smaller businesses that may not be able to achieve sufficient economies of scale to make workplace charging feasible. However, in the case of Beverly Hills, the city ranks highly on the attribute of a high number of white-collar workers that may be early adopters of PEVs. This attribute is explored further in Section 7.2.4.

Table 7.1: Los Angeles County cities by number of employees and workplaces, 2012

Cities by employees	Number of workplaces
Los Angeles (1,683,000)	169,000
Long Beach (154,000)	13,000
Torrance (114,000)	10,000
Pasadena (110,000)	9,000
Burbank (91,000)	8,000
Glendale (91,000)	8,000
Santa Monica (84,000)	Beverly Hills (7,000)
Carson (75,000)	7,000
Industry (68,000)	6,000
Santa Clarita (66,000)	Inglewood (4,000)

7.2.2 How significant are workplaces compared to other types of parcels?

The previous two metrics simply assess workplace charging potential in terms of raw numbers. The actual priorities of a local jurisdiction may differ based on the relative percentage of employees compared to potential residential users of PEV charging. For example, a bedroom community may choose not to prioritize workplace charging if residents significantly outnumber employees.

A third way to assess workplace charging potential is by ranking cities that have the highest shares of employees relative to single-family homes and multi-unit dwellings (MUDs). This type of analysis can help cities align their PEV readiness priorities with their land uses. It can also indicate cities that may wish to prioritize workplace planning for PEVs, even if they will not have a significant regional impact in doing so. For the COG, such a ranking may indicate which cities may be receptive to technical assistance on PEV planning for workplaces.

This measurement assumes that the total number of residential units and employees represent the potential demand for PEV charging spots at homes and workplaces. This measurement accounts for the number of employees, not employers. This is because larger workplaces will be more likely to install PEV charging, as it will be more cost-effective for them to do so than for small businesses.

Cities that have a relatively high percentage of employees relative to single-family homes and MUDs are potentially strong candidates for workplace charging initiatives. The percentages in Table 7.2 represent shares of the combined total number of MUD units, single-family units, and employees in each city. They are ranked in order of the percentage of uses within each city that is made up of employees.[18]

Table 7.2: Los Angeles County cities by share of employees, single-family residential units, and MUD units

City	Employee %	SF %	MUD %
Industry	100%	0%	0%
Vernon	100%	0%	0%
Irwindale	96%	2%	2%
Commerce	95%	3%	2%
Santa Fe Springs	93%	5%	2%
South El Monte	86%	10%	4%
La Verne	83%	13%	4%
El Segundo	82%	7%	11%
Westlake Village	81%	15%	4%
Beverly Hills	79%	8%	14%

7.2.3 What are the largest employers and where are they located?

Workplaces with large numbers of employees may be better-positioned than small businesses to recover costs from offering PEV charging due to higher potential usage. Determining which employers are the largest will help city planners target outreach efforts and help utilities prioritize locations for transformer and power distribution upgrades.

18 Information on housing units was obtained from 2007 Los Angeles County Assessor data.

Table 7.3 presents an example of aggregated rankings from Infogroup of the top employers in Los Angeles County by the number of employees. Excluding fossil-fuel firms that may not be motivated to adopt workplace charging, the list reveals employers with a focus on research, technology, health and entertainment. Such firms may be interested in promoting their mission by hosting PEV charging or attracting workers who are prospective PEV drivers.

Table 7.3: Top Los Angeles County employers by number of employees and firm type

Employers (overall)	Number of employees	Non-fossil-fuel firms	Number of employees
UCLA	36,000	UCLA	36,000
USC	12,000	USC	12,000
L.A. Police Dept.	9,000	L.A. Police Dept.	9,000
L.A. County Medical Ctr.	8,000	L.A. County Medical Ctr.	8,000
Pacific Enterprises	7,000	Pacific Enterprises	7,000
Jet Propulsion Lab.	6,000	Jet Propulsion Lab.	6,000
Westcoast	6,000	Westcoast	6,000
BP West Coast Products	6,000	Walt Disney Co.	6,000
BP Carson Refinery	6,000	Kaiser Foundation Hospital	5,000
Walt Disney Co.	6,000	Kaiser Permanente	5,000

7.2.4 Which employers have the highest numbers of white-collar and high-tech workers?

Studies of PEV buyers to date have shown that they tend to be high-income, college-educated homeowners (CCSE 2012; Landy 2011; Southern California Edison 2012). Another metric by which to prioritize cities and employers for workplace charging is the number of white-collar workers. An example from Los Angeles County is shown in Table 7.4 below.

Table 7.4: Top Los Angeles County cities and employers, by number of white-collar workers

Number of white-collar employees	Number of white-collar employees (overall)	Number of white-collar employees (non-fossil fuel firms)
Los Angeles (1,005,000)	UCLA (31,000)	UCLA (31,000)
Long Beach (83,000)	USC (11,000)	USC (11,000)
Pasadena (72,000)	L.A. County Medical Ctr. (7,000)	L.A. County Medical Ctr. (7,000)
Torrance (66,000)	Jet Propulsion Lab. (6,000)	Jet Propulsion Lab. (6,000)
Burbank (59,000)	Westcoast (5,000)	Westcoast (5,000)
Glendale (57,000)	Kaiser Permanente (5,000)	Kaiser Permanente (5,000)
Santa Monica (53,000)	Walt Disney Co. (5,000)	Walt Disney Co. (5,000)
Carson (43,000)	Kaiser Foundation Hospital (5,000)	Kaiser Foundation Hospital (5,000)
Beverly Hills (38,000)	BP West Coast Products (4,000)	Pacific Enterprises (4,000)
Santa Clarita (37,000)	BP Carson Refinery (4,000)	VA Greater Los Angeles Health (4,000)

Similarly, cities with the highest numbers of high-tech workplaces may be strong candidates for technical assistance for workplace charging, or outreach to employers. An example from Los Angeles County is shown in Table 7.5 below.

Table 7.5: Los Angeles County cities by number of high-tech workplaces

City	Number of high-tech workplaces
Los Angeles	3,089
Torrance	286
Glendale	247
Industry	194
Santa Monica	175
Pasadena	172
Burbank	158
Long Beach	155
Santa Clarita	143
El Segundo	111

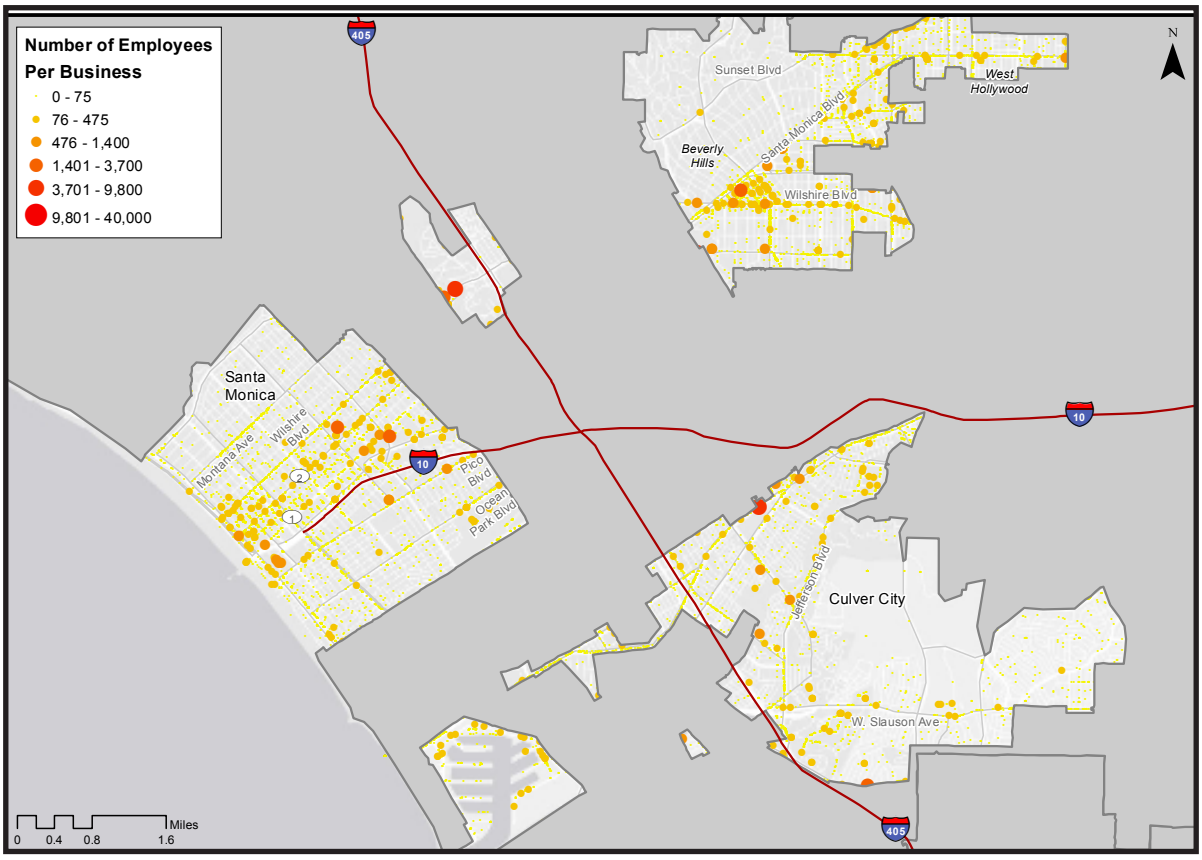
Cities and COGs may want to conduct more than one of the analyses presented above to cross-check the rankings of cities and employers. Cities and workplaces that rank higher using multiple metrics are likely to be good targets for workplace charging initiatives.

7.2.5 Which employers are located in neighborhoods where current PEV owners drive on weekday mornings?

The COG-level maps in the Southern California PEV Atlas that accompanies this document overlay employment centers of different sizes with densities of PEVs traveling to daytime destinations. Planners and utilities can use these maps to compare the spatial distribution of employers and daytime travel destinations for PEVs. Examples from the Westside Cities Council of Governments are provided below.

The maps overlaying employment density were prepared using 2008 Infogroup data on employer size (i.e., number of employees) and location. Each circle on the map represents one workplace. The circles move from small to large and from yellow to red as the number of employees per workplace increases. While the largest, reddest circles represent the largest workplaces (and thus locations that may be amenable to providing charging on-site), areas rich in small workplaces may represent demand for charging streetside or in stand-alone parking structures. Parking structures that are not attached to other land uses are also mapped at the COG level in the Southern California PEV Atlas that accompanies this document.

Map 7.1: Employment density, Westside Cities Council of Governments

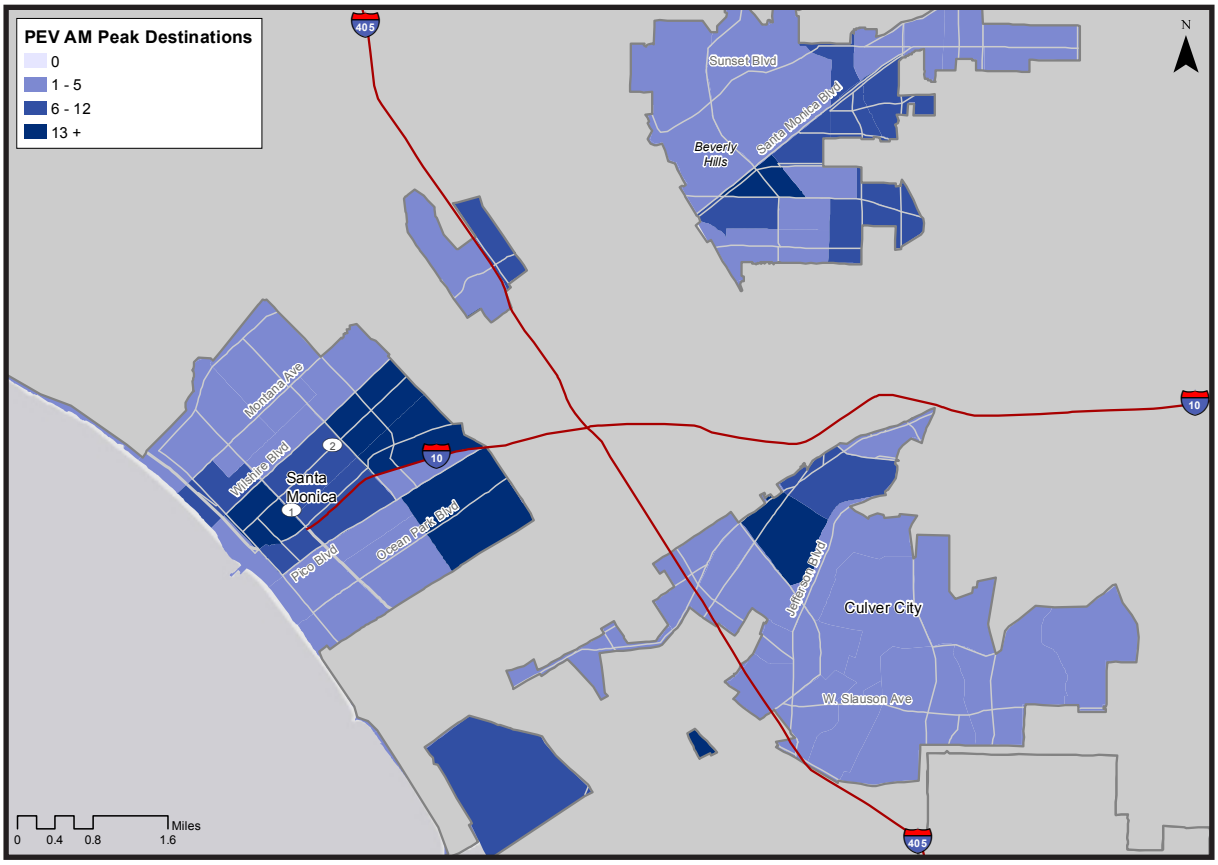


After mapping employment densities, the UCLA Luskin Center mapped the locations where

currently-registered PEVs are traveling during morning weekday rush hour. The data on PEV registrations comes from automotive data vendor R.L. Polk & Co., which provided the number of PEVs registered as new within each Census tract through September 2012. These Census tracts represent the neighborhoods where PEVs originate their trips from home.

Census tracts closely follow the boundaries of travel analysis zones (TAZs), which are the geographic areas used by the Southern California Association of Governments to model vehicle travel. Using a network of sensors located on streets, SCAG's travel demand model estimates the number of trips from home to work, school, and other destinations by time of day. By counting the number of PEVs from each *origin* TAZ that feed into each of the daytime *destination* TAZs, we are able to map the locations and densities of PEVs traveling to work. The neighborhoods where PEVs travel during the day are the daytime destinations mapped in example Map 7.2.

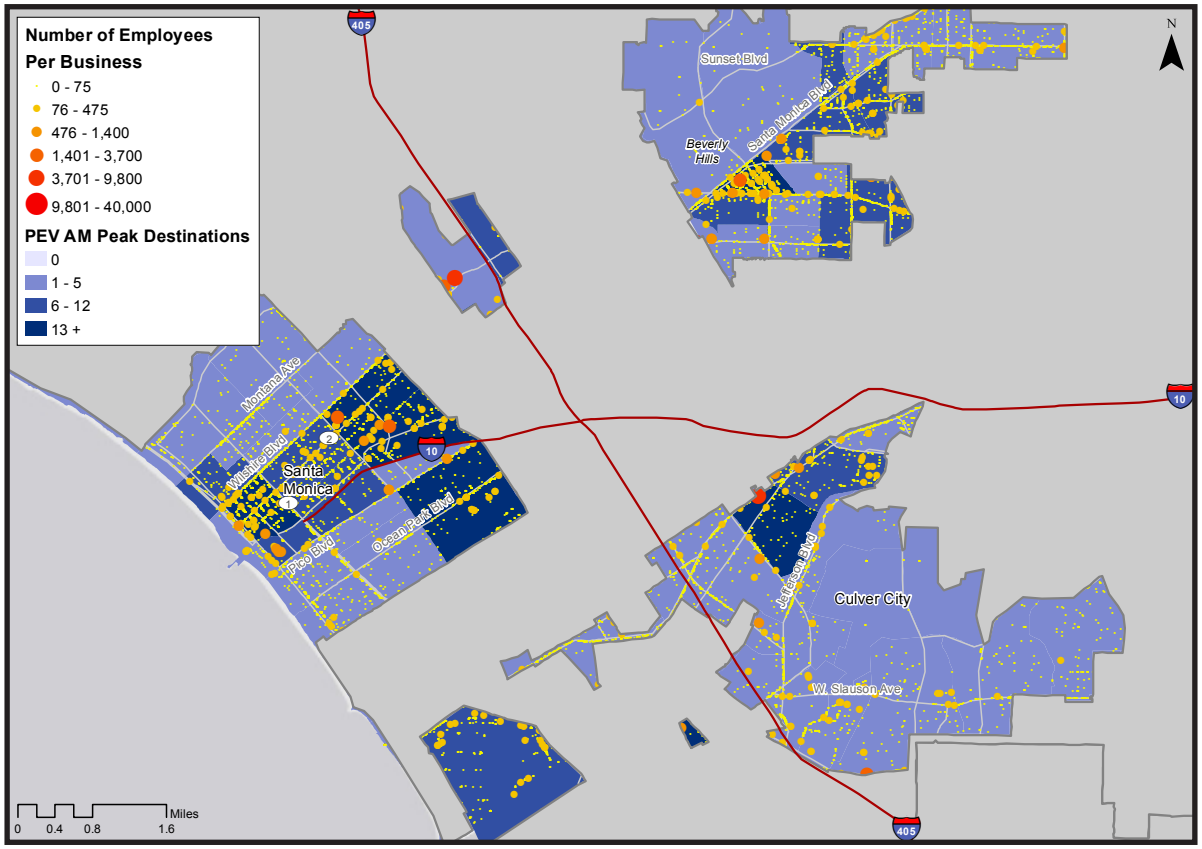
Map 7.2: PEV daytime destinations, Westside Cities Council of Governments



Example Map 7.3 on the next page combines the previous two maps [Map 7.1 and Map 7.2] into an overlay of employment density and daytime PEV destinations. Planners should consult the COG-level maps in the Southern California PEV Atlas that accompanies this document to assess existing potential demand for workplace charging. Combined with the metrics described

earlier in this chapter, the data will provide a strategic approach to prioritizing workplace charging resources, policies and incentives. Recommendations for such policies and incentives are provided later in this chapter.

Map 7.3: PEV daytime destinations and workplaces, Westside Cities Council of Governments



7.3 The workplace PEV charging installation process

The process of setting up charging at workplaces requires the cooperation of the parties that own and operate the company's parking area. Some employers own their own buildings and dedicated parking areas. Other employers lease parking from commercial landlords, who in turn may contract with a parking management company to operate the lot or structure.

The diagram [Figure 7.1] on the next page presents the basic process for installing workplace charging. While many of the steps require internal decision-making at the company level, other decision points involve interactions with utilities and city departments. These stakeholders can help clear the way for workplace charging with proper incentives and installation approval procedures. They can also be a valuable source of information for employers considering workplace charging.

Figure 7.1: The workplace PEV charging installation process

Source: (California Plug-in Electric Vehicle Collaborative 2012)

7.4 Planning for workplace charging

Local planners and utilities can facilitate workplace charging in two ways: 1) by providing information to employers considering workplace charging and 2) reducing the hard and soft costs of workplace charging. The following sections give examples of factors employers will need to consider when making the workplace charging decision as well as examples of typical barriers they encounter.

7.4.1 Typical workplace charging considerations

Planners should make employers aware of the following considerations as they consider whether to install workplace charging. These are divided into pre-planning, installation and economic considerations.

7.4.2 Pre-planning

If the employer does not own or operate the parking area, how will charging be installed? Some landlords may be willing to share costs with employer tenants; others may not. Employers and/or property owners must decide if providing PEV charging is a worthy investment as a present and future amenity for employer tenants and/or employees. A cost recovery model for employers is presented in Table 7.5.

Will Level 1 charging be sufficient to meet demand? Existing outlets in the parking area may be sufficient to provide a slow charge, which will work for PEVs with small batteries and those that are parked all day, as well as for drivers with relatively short commutes. Level 1 charging may help employers avoid incurring Level 2 equipment, installation, and permitting costs.

What incentives are available for workplace charging? Some utilities may offer a non-residential time-of-use rate that provides a discount on electricity used for PEV charging, particularly during morning hours. The EV Project demonstration program and electric vehicle service provider ChargePoint are providing free charging stations to interested workplaces.

7.4.3 Installation

How can the employer comply with disabled access requirements for PEV charging? Consistent installation and signage standards across jurisdictions will lay the groundwork for future state or regional ordinances. The California PEV Collaborative provides guidelines on disabled accessibility and sample drawings for public- and restricted-access charging spaces in both new construction and existing facilities. These guidelines are discussed in further detail in Chapter 13 of this document.

How many chargers should be installed? Employers should survey their employees to assess demand for PEV charging. California's green building code provides guidance on voluntary measures municipalities can adopt if they want to require PEV charging readiness in newly-constructed non-residential buildings. The recommendation calls for one charging space for every 50 parking spaces. Further guidance on building codes and parking are provided in Chapter 11 and Chapter 13 of this document.

7.4.4 Economic considerations

How can peak electricity rates and demand charges be avoided? Workplaces can sign up for time-of-use electricity rates for PEV charging that provide a discount for charging during pre-

peak morning hours. Workplaces can also conduct energy audits to identify potential cost savings and enroll in a demand-response program to reduce energy consumption during peak load times.

How can the employer plan for future PEV charging demand? A typical commercial charging unit has several connectors that allow multiple vehicles to charge simultaneously. Some units combine Level 1 and Level 2 charging on the same unit, allowing the driver to choose a slower, more cost-effective charge if that is sufficient.

What is the typical cost of charging units and electrical upgrades? Equipment and installation costs can run a few thousand dollars, but vary widely depending on the power level, number of vehicles that can be charged simultaneously, and the level of sophistication (i.e., whether the unit has access control, wireless connectivity and usage tracking). Electrical upgrades can also run in the thousands of dollars, but planners can shift these costs to developers by requiring PEV readiness at the time new commercial buildings are constructed.

How can the employer recover equipment and operating costs? Pricing that is cost-effective for both workplace site hosts and PEV drivers will maximize electric miles traveled. Understanding various pricing models will help planners provide technical assistance to employers. We present these models in the next section.

7.5 Financial viability of workplace charging

A central concern of most employers is whether workplace charging will be financially viable. They want to know whether they can at least break even on their investment. In this section, we first present a set of questions facing employers who wish to make well-informed investments in charging equipment. We then explore the financial viability of several types of investment scenarios involving early- and then middle-market demand for workplace charging. We conclude that the two most transparent and effective policies are a variable cost with a markup and, to a lesser extent, an hourly rate policy.

Planners who wish to advise employers on pricing alternatives should also see Chapter 9.

7.5.1 How much employee demand will there be for PEV charging?

In order to assess employee demand for PEV charging, employers will want to know:

- How many employees are currently driving PEVs to work?
- How will this number grow over time?
- Will they charge at work if equipment is available?

Some employees may not need to charge at work in order to complete their daily commuting route on electric miles. Most employees are likely to make this decision by comparing the costs of charging at work with their costs of refueling elsewhere, such as charging at home or filling

up with gasoline if they drive a plug-in hybrid (PHEV).

7.5.2 How should the employer price PEV charging?

Once the employer estimates the demand for workplace charging, he or she must decide how to price the service. Understanding potential demand will help the employer determine how much electricity employees will consume for PEV charging and what revenues will be generated by pricing use of the equipment. (See Chapter 9 for a discussion of alternative pricing policies.)

A danger that employers face is pricing workplace charging at levels greater than employees pay elsewhere. In this case, employees with PEVs may not choose to charge at work and the employer will fail to generate the expected revenue. Another danger is pricing charging at levels too low to cover the employer's costs. In our analysis below, we consider both of these possible errors when evaluating the financial viability of workplace charging scenarios.

7.5.3 How much charging capacity should the employer provide?

Capacity here refers to the number of cords of each level (1, 2 or fast charging) provided at the location. Currently, single-cord Level 2 chargers are popular. But this may not necessarily be the best capacity for employers to choose. If the employer expects multiple employees to adopt PEVs, then multiple-cord (or multiplex) charging units with different levels of service (1 and 2) could be an employer's most cost-effective solution. Although the upfront costs can be higher, the multiplex chargers, when charging several vehicles at once, may do so at a lower total cost and lower cost per unit of electricity than would a comparable number of single-cord Level 2 chargers. In practice, identifying the most cost-effective choice of charging capacity requires comparing the costs of specific types of charging equipment and how much it will be used in a specific workplace setting.

7.5.4 Financial viability scenarios

The goal of the next sections is to give planners an understanding of how installed charger costs, pricing policy, and driver utilization rates affect the financial viability of workplace charging. Using simple cash-flow models, we describe the net loss or net profit of workplace charging under a wide range of conditions. These examples are intended only as illustrations but are based on commonly-encountered assumptions.[19] We will consistently evaluate the impacts of

19 We assume employers (or a contracted electric vehicle service provider) will own and operate the charge station every day for 10 years and that the employer pays $0.195 per kilowatt-hour (kWh) for electricity. (This is based on what a typical home would pay on average in the Southern California Edison service territory. Smaller businesses tend to pay more than this rate per kWh and larger businesses tend to pay less. We hold electricity costs constant across our analyses in this Plan in order to simplify comparisons across charging environments). When calculating the net present value we assume the employer's discount rate is 5%. Variable costs (electricity and markup) grow at a rate of 3% a year. Operation and maintenance costs are assumed to be 5% of total fixed costs.

wide a range of installed equipment costs, from a low of $500 to a high of $10,000.[20]

7.5.5 Recovering costs of charging the first PEV

Given that drivers have only just begun to purchase PEVs, many employers are considering installing workplace charging for a single "first" PEV. How much is that first PEV utilizing workplace charging equipment? The average driver in United States metropolitan areas travels 30 miles per day. So a reasonable assumption would be that the PEV arrives to work having driven 15 electric miles. This means the driver could restore the electricity used to drive those 15 miles to the battery through workplace charging. For the employer, the revenues that would be generated from that utilization rate require an understanding of what the PEV driver will pay for charging. Our analysis below will identify what workplace prices PEV drivers would be willing to pay based on their cost of charging at home and the price of gasoline.

Since most PEV charging will be done at home where it is most convenient and cost-effective, we can assume that the first PEV driver will be willing to pay no more than what he or she pays to charge at home. This translates to a price that covers a residential investment of about $2,000 or less. Therefore, employers should first assess their capacity to support Level 1 charging, since it involves the lowest installation and equipment costs. If pre-existing Level 1 outlets are available, and the building's electrical capacity is adequate, the only costs the employer may face are those associated with measuring how much electricity employees consume and billing employees.

In the following scenario analysis, we explore the impacts of four different types of pricing policies: 1) flat monthly or subscription fees, 2) hourly rate, 3) hourly with connection fee, and 4) cost plus a markup. See Table 7.6, Table 7.7, Table 7.8, and Table 7.9, respectively. Within each table we use six different pricing levels and 11 different possible installed charger costs to calculate the present value (or net profits) for the employer for 66 different pricing scenarios. Each assumes a Level 2 charging rate.

Planners can use the tables in this section to assess financial viability of hosting a charging station from the **employer/site owner's** perspective. When used in conjunction with the tables in Chapter 9, planners can evaluate the pricing models presented here against the cost to the **driver** under the same pricing models.

First, the planner can identify investment costs and pricing levels under which employers would at least break even, given this level of utilization. Second, the planner can evaluate the workplace prices that are likely to be above the PEV driver's residential or gasoline cost of refueling. This latter assessment is critical for the employer because it identifies those prices that will not generate any revenues for the workplace charge station. Of course, another danger

20 This installed charger costs represent the total upfront costs including charging space design, permitting, electrical upgrades, construction, installation, and the cost of charging equipment.

for the employer is pricing charging at levels too low to cover costs. In our analysis below, we consider both of these possible errors when evaluating the financial viability of workplace charging scenarios.

Monthly Flat Rates. Table 7.6 illustrates the present value calculation for flat rates or monthly subscriptions ranging from $25 to $150 per month. We see again that several price levels would enable the employer to break even: $50 a month would cover up to $1,000 in investment costs while $75 a month would cover up to $3,000. However, even at the low levels of investment, only very high e-mileage drivers would find it cost-effective to charge at work under a flat rate. Higher monthly fees would not be cost-effective for even high e-mileage drivers.

Table 7.6: Present value of workplace charging to site owner over 10 years (monthly rate)

Installed Charger Cost	Monthly Rate $ 25.00	$ 50.00	$ 75.00	$ 100.00	$ 125.00	$ 150.00
$ 500	$ (1,223)	$ 1,401	$ 4,026	$ 6,650	$ 9,274	$ 11,898
$ 1,000	$ (1,942)	$ 683	$ 3,307	$ 5,931	$ 8,556	$ 11,180
$ 2,000	$ (3,379)	$ (755)	$ 1,870	$ 4,494	$ 7,118	$ 9,742
$ 3,000	$ (4,816)	$ (2,192)	$ 432	$ 3,056	$ 5,681	$ 8,305
$ 4,000	$ (6,254)	$ (3,629)	$ (1,005)	$ 1,619	$ 4,243	$ 6,868
$ 5,000	$ (7,691)	$ (5,067)	$ (2,443)	$ 182	$ 2,806	$ 5,430
$ 6,000	$ (9,128)	$ (6,504)	$ (3,880)	$ (1,256)	$ 1,369	$ 3,993
$ 7,000	$ (10,566)	$ (7,942)	$ (5,317)	$ (2,693)	$ (69)	$ 2,556
$ 8,000	$ (12,003)	$ (9,379)	$ (6,755)	$ (4,130)	$ (1,506)	$ 1,118
$ 9,000	$ (13,441)	$ (10,816)	$ (8,192)	$ (5,568)	$ (2,944)	$ (319)
$ 10,000	$ (14,878)	$ (12,254)	$ (9,629)	$ (7,005)	$ (4,381)	$ (1,757)

Hourly Rates. Table 7.7 illustrates the present value calculation for hourly rates ranging from $0.50 to $3.00. It assumes a Level 2 charging rate. In order for the employer to break even on serving the first PEV, the investment costs of $1,000 or less would need to be priced at least at $1.50 per hour. This workplace price would be cost-effective for some but not all PEV drivers. The price of $1.50 per hour is approximately equal to $3.60 per gallon—less than it would cost PEV drivers to fill up at the pump. Thus, those PEV drivers with battery ranges less than their roundtrip commute will find it cost-effective to charge at work.

However, for those PEV drivers that can effectively commute to and from work without recharging, we see from Table 7.7 that they can most likely recharge at home more cost effectively (e.g., for less than $3.60) than they can at work. Because a price of $2.00 per hour is equivalent to $4.81 a gallon, we would expect to see only the rare BEV driver who faces being stranded to be willing to pay more than it would cost to charge at home or fill up with gas. Thus, any price per hour equal to or greater than $2.00 an hour is unlikely to generate utilization, and thus revenues, for employers.

Table 7.7: Present value of workplace charging to site owner over 10 years (hourly rate)

Installed Charger Cost	Hourly Rate $ 0.50	$ 1.00	$ 1.50	$ 2.00	$ 2.50	$ 3.00
$ 500	$ (1,930)	$ (14)	$ 1,903	$ 3,820	$ 5,737	$ 7,653
$ 1,000	$ (2,649)	$ (732)	$ 1,184	$ 3,101	$ 5,018	$ 6,935
$ 2,000	$ (4,086)	$ (2,170)	$ (253)	$ 1,664	$ 3,581	$ 5,497
$ 3,000	$ (5,524)	$ (3,607)	$ (1,690)	$ 226	$ 2,143	$ 4,060
$ 4,000	$ (6,961)	$ (5,044)	$ (3,128)	$ (1,211)	$ 706	$ 2,623
$ 5,000	$ (8,399)	$ (6,482)	$ (4,565)	$ (2,648)	$ (732)	$ 1,185
$ 6,000	$ (9,836)	$ (7,919)	$ (6,003)	$ (4,086)	$ (2,169)	$ (252)
$ 7,000	$ (11,273)	$ (9,357)	$ (7,440)	$ (5,523)	$ (3,606)	$ (1,690)
$ 8,000	$ (12,711)	$ (10,794)	$ (8,877)	$ (6,961)	$ (5,044)	$ (3,127)
$ 9,000	$ (14,148)	$ (12,231)	$ (10,315)	$ (8,398)	$ (6,481)	$ (4,564)
$ 10,000	$ (15,586)	$ (13,669)	$ (11,752)	$ (9,835)	$ (7,919)	$ (6,002)

Hourly Rate Plus Connection Fees. Table 7.8 illustrates the present value calculation for hourly rates ranging from $0.50 to $3.00 plus a connection fee of $1.00. We see again that while several price levels would enable the employer to break even, most of these price levels would mean that workplace charging would not be cost-effective to most PEV drivers. In order for the employer to break even on serving the first PEV, the investment costs of $1,000 or less would need to be priced at least at $0.50 per hour. Prices set at $1.00 would cover investment costs of $2,000 while prices of $1.50 per hour would cover up to $4,000 in investment costs. Unfortunately, while $0.50 an hour plus a $1.00 connection fee would be cost-effective for most PEV drivers, $1.00 per hour plus a $1.00 connection fee would be cost-effective for only those driving more than about 20 electric miles. (Recall from Chapter 5 and Chapter 9 that the effective cost per electric mile varies with the number of e-miles driven when drivers charge at home).

Table 7.8: Present value of workplace charging to site owner over 10 years (hourly rate plus $1.00 connection fee)

Installed Charger Cost	Hourly Rate $ 0.50	$ 1.00	$ 1.50	$ 2.00	$ 2.50	$ 3.00
$ 500	$ 1,262	$ 3,179	$ 5,096	$ 7,013	$ 8,929	$ 10,846
$ 1,000	$ 544	$ 2,461	$ 4,377	$ 6,294	$ 8,211	$ 10,128
$ 2,000	$ (894)	$ 1,023	$ 2,940	$ 4,857	$ 6,773	$ 8,690
$ 3,000	$ (2,331)	$ (414)	$ 1,503	$ 3,419	$ 5,336	$ 7,253
$ 4,000	$ (3,768)	$ (1,852)	$ 65	$ 1,982	$ 3,899	$ 5,815
$ 5,000	$ (5,206)	$ (3,289)	$ (1,372)	$ 545	$ 2,461	$ 4,378
$ 6,000	$ (6,643)	$ (4,726)	$ (2,810)	$ (893)	$ 1,024	$ 2,941
$ 7,000	$ (8,081)	$ (6,164)	$ (4,247)	$ (2,330)	$ (413)	$ 1,503
$ 8,000	$ (9,518)	$ (7,601)	$ (5,684)	$ (3,768)	$ (1,851)	$ 66
$ 9,000	$ (10,955)	$ (9,039)	$ (7,122)	$ (5,205)	$ (3,288)	$ (1,372)
$ 10,000	$ (12,393)	$ (10,476)	$ (8,559)	$ (6,642)	$ (4,726)	$ (2,809)

Variable Costs Plus a Markup. Table 7.9 illustrates the present value calculation for variable costs plus a markup ranging from zero to $0.30. Identifying the set of prices that are both cost-effective for PEV drivers and yield a positive present value, we see that a markup of $0.25 or less would generate enough revenue to support up to a $2,000 investment plus ongoing variable costs.

Table 7.9: Present value of workplace charging to site owner over 10 years (markup on electricity)

Installed Charger Cost	Markup $ -	$ 0.10	$ 0.15	$ 0.20	$ 0.25	$ 0.30
$ 500	$ (719)	$ 949	$ 1,783	$ 2,617	$ 3,450	$ 4,284
$ 1,000	$ (1,437)	$ 230	$ 1,064	$ 1,898	$ 2,732	$ 3,566
$ 2,000	$ (2,875)	$ (1,207)	$ (373)	$ 461	$ 1,294	$ 2,128
$ 3,000	$ (4,312)	$ (2,645)	$ (1,811)	$ (977)	$ (143)	$ 691
$ 4,000	$ (5,750)	$ (4,082)	$ (3,248)	$ (2,414)	$ (1,580)	$ (747)
$ 5,000	$ (7,187)	$ (5,519)	$ (4,685)	$ (3,852)	$ (3,018)	$ (2,184)
$ 6,000	$ (8,624)	$ (6,957)	$ (6,123)	$ (5,289)	$ (4,455)	$ (3,621)
$ 7,000	$ (10,062)	$ (8,394)	$ (7,560)	$ (6,726)	$ (5,893)	$ (5,059)
$ 8,000	$ (11,499)	$ (9,831)	$ (8,998)	$ (8,164)	$ (7,330)	$ (6,496)
$ 9,000	$ (12,936)	$ (11,269)	$ (10,435)	$ (9,601)	$ (8,767)	$ (7,934)
$ 10,000	$ (14,374)	$ (12,706)	$ (11,872)	$ (11,039)	$ (10,205)	$ (9,371)

7.5.6 Recovering the costs of charging several PEVs

The financial viability of workplace charging improves considerably once several PEVs find it cost-effective to charge at work. Table 7.10 assumes the charging is priced at variable costs plus a $0.20 markup—the equivalent of about $3.64 per gallon in the first year. The net present value (over 10 years) is evaluated for installed charger costs ranging from $500 to $10,000 and for vehicles needing to charge enough to replace 10 to 120 e-miles driven. As such, the table represents 99 different investment-utilization scenarios.

Table 7.10: Present value of workplace charging to site owner with markup, by utilization level

Installed Charger Cost	Daily Electric Miles	10	15	30	45	60	75	90	105	120
	Hours - Utilization	0.91	1.36	2.72	4.08	5.44	6.80	8.16	9.52	10.88
$	500	$ 1,505	$ 2,617	$ 5,952	$ 9,287	$ 12,622	$ 15,958	$ 19,293	$ 22,628	$ 25,964
$	1,000	$ 786	$ 1,898	$ 5,233	$ 8,568	$ 11,904	$ 15,239	$ 18,574	$ 21,910	$ 25,245
$	2,000	$ (651)	$ 461	$ 3,796	$ 7,131	$ 10,466	$ 13,802	$ 17,137	$ 20,472	$ 23,807
$	3,000	$ (2,089)	$ (977)	$ 2,358	$ 5,694	$ 9,029	$ 12,364	$ 15,700	$ 19,035	$ 22,370
$	4,000	$ (3,526)	$ (2,414)	$ 921	$ 4,256	$ 7,592	$ 10,927	$ 14,262	$ 17,597	$ 20,933
$	5,000	$ (4,963)	$ (3,852)	$ (516)	$ 2,819	$ 6,154	$ 9,489	$ 12,825	$ 16,160	$ 19,495
$	6,000	$ (6,401)	$ (5,289)	$ (1,954)	$ 1,382	$ 4,717	$ 8,052	$ 11,387	$ 14,723	$ 18,058
$	7,000	$ (7,838)	$ (6,726)	$ (3,391)	$ (56)	$ 3,279	$ 6,615	$ 9,950	$ 13,285	$ 16,621
$	8,000	$ (9,276)	$ (8,164)	$ (4,828)	$ (1,493)	$ 1,842	$ 5,177	$ 8,513	$ 11,848	$ 15,183
$	9,000	$ (10,713)	$ (9,601)	$ (6,266)	$ (2,931)	$ 405	$ 3,740	$ 7,075	$ 10,411	$ 13,746
$	10,000	$ (12,150)	$ (11,039)	$ (7,703)	$ (4,368)	$ (1,033)	$ 2,303	$ 5,638	$ 8,973	$ 12,308

A useful way of interpreting Table 7.10 is to recognize that each additional PEV at the workplace means an additional 15 e-miles that would be recharged at work. Adding a second, third, fourth, and fifth PEV represent an increase in e-miles of 30, 45, 60, and 75 respectively. From Table 7.10 we can see that the addition of a second vehicle (30 e-miles) using workplace charging yields enough revenue to support $4,000 of investment. Scaling up further, the addition of a third, fourth and fifth PEV supports $6,000, $9,000 and well over $10,000 of financially-viable investment respectively. In other words, if employers can size their charge stations to charge at least four vehicles at once for under $9,000, then they can break even while charging drivers competitive rates. An associated challenge is that employers must

accurately guess the growth of PEV demand for their workplace charge stations. The risk for employers is that utilization rates in the form of additional PEVs may not grow fast enough to cover costs.

7.5.7 Selecting Pricing Policies for Workplace Charging

The two most transparent and effective policies are the variable cost with a markup and, to a lesser extent, the hourly rate policy. The hourly rate policy does have the disadvantage of potentially discriminating against older PEV models that charge more slowly and thus will pay more than will new PEVs. It may also discriminate against vehicles that do not require a lot of charge. For example, it may only take roughly one and a half hours to recharge the 15-mile commute. Unless drivers move their cars or are not billed for the time after charging is completed, their costs per kilowatt-hour continue to rise, quickly reaching uncompetitive levels.

Both the markup and hourly rate policies come with the added costs to employers of measuring and billing for the quantity of electricity or time that PEVs consume. Flat-rate policies, in contrast, avoid these measurement and billing costs to employers but have the disadvantage of imposing different unit costs (e.g., cost per electric mile driven) on PEV drivers who travel differing numbers of e-miles daily. (See Chapter 9 for a more detailed discussion of how to design pricing policies.)

7.5.8 Institutional and physical barriers to PEV charging

Location, availability and management of on-site parking. Some workplaces have assigned parking spaces, which makes it difficult to convert the spaces closest to the electrical room to PEV spaces. The farther away from the electrical room the charger is located, the more expensive it will be to lay conduit and wiring.

The distance between where the PEV is parked and the electrical panel is a major factor in installation costs, permitting and inspection processes. Workplaces with surface parking may have the greatest distances between where cars are parked and where service panels are located, and may require trenching. This can incur more in the way of construction costs and soft costs associated with permitting and inspection.

Employees could be encouraged to trade parking spots or use a common or visitor space for PEV charging. Employers and/or property owners can convert visitor spaces to assigned PEV parking or temporary charging. They can also encourage employees to trade parking spots to put the PEVs as close as possible to the electrical room.

The cost of charger installation and electrical upgrades. Parking areas often have just enough electrical capacity to support lighting and other basic garage functions. Level 1 charging may only require adding 120-volt outlets, but panel upgrades may be needed to support Level 2 charging. If subsidies for charging equipment and installation require Level 2 charging, employers and/or property owners may be deterred from taking advantage of the subsidies

because of the cost of adding panel capacity. Adding panel capacity can incur hard costs of wiring upgrades as well as soft costs of permitting and inspection.

Building codes offer an opportunity to require PEV-ready wiring in new construction—a much more cost-effective method than retrofits. These codes, as well as equipment subsidies and rate incentives from local jurisdictions and/or utilities, could be adapted to facilitate more Level 1 charging capabilities. Further guidance on building codes for PEV readiness is provided in Chapter 11.

7.6 Recommendations for facilitating workplace charging

Installing PEV chargers in workplaces presents a number of institutional, physical and cost recovery challenges. Local planners and policymakers can make the greatest impact in reducing the hard and soft costs of installation. To expand charging in the nearer term, local policymakers should consider the following measures, in addition to the recommendations provided earlier in this chapter and in related chapters:

7.6.1 Utility policies

- Plan capital projects to upgrade electrical distribution systems to accommodate PEV charging in workplace- or employee-dense areas.
- Prioritize upgrades of transformers that enable PEV charging at workplaces.
- Partially subsidize costs associated with slower, lower-voltage Level 1 charging, which may only require some additional standard outlets in the parking area. Extending partial subsidies to Level 1 charging would allow existing power supplies to go farther by reducing the need for electrical upgrades. This could also potentially lower the time and cost associated with permitting and inspection.[21]
- Subsidies for charger purchase and installation should be made available to employers (in addition to drivers), as they are well-positioned to achieve economies of scale with multiple installations, and can reap the benefit over the long run by providing an attractive amenity (Balmin, Bonett, and Kirkeby 2012).[22]

7.6.2 Regional planners

- Conduct demonstration projects to research ways of reaching economies of scale with

21 Some utilities may wish to directly subsidize purchase and installation of charging units, as the Los Angeles Department of Water and Power does currently with its Charge Up L.A.! program. But if these incentives are designed around faster, higher-voltage Level 2 charging, they will require the purchase of special equipment and most likely require an electrical upgrade. Level 2 charging can thus incur potentially higher upfront costs and a more complex permitting process, slowing PEV adoption.

22 Employers who are not property owners may not want to pay for electrical upgrades because they will lose the benefit when they move.

PEV charging at workplaces.

- Target and support workplace charging within the region based on the metrics described here and elsewhere in this document.

7.6.3 Local planners

- Reform building codes to require a certain number of Level 1 and Level 2 PEV-ready spaces in new non-residential construction. This is the most cost-effective, least institutionally complicated method of ensuring more workplace charging opportunities in the future.
- Allow PEV charging spaces to count towards minimum parking requirements or offer them as a development incentive. Further guidance on these measures is provided in Chapter 10 of this document.
- Streamline permitting and inspection procedures for PEV charging installations. Further guidance is provided in Chapter 12 of this document.
- Automatically expedite the approval process for PEV charging permits in workplaces.
- Conduct employer-specific outreach activities and provide educational materials to employers and commercial property owners. These materials should specify the process of installing charging in workplaces and present cost recovery models. Further guidance on outreach is provided in Chapter 15.

7.7 References

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9 Pricing Policies for PEV Infrastructure

9.1 Introduction

When prices for plug-in electric vehicle (PEV) charging are designed correctly, they facilitate the growth of a financially-sustainable universe of charging options. Good pricing policies provide PEV drivers with fair, efficient access to a variety of charging levels. They also help charging site hosts or operators cover costs. Since drivers will seek out the lowest-priced stations, prospective site hosts look for locations with the lowest costs and highest demand.

As planners seek to maximize the number of electric miles driven in their jurisdiction, they need to understand the refueling behavior of PEV drivers. Charge station pricing policies will determine where and when drivers choose to refuel, thus informing where additional new stations and which existing stations will be financially viable under current pricing policies.

Charge station pricing policies are important for planners to understand for other reasons. Planners may have to:

- **Set prices** for use of charge stations on public property, such as parking structures, libraries, city hall, or public recreational destinations. They may also set prices in their capacity as an employer providing workplace charging.
- **Contract with a charge station network service provider** (also called an electric vehicle service provider, or EVSP). EVSPs provide a wide variety of charging services, including equipment installation, billing, and usage tracking. EVSPs can be contracted to operate charge stations on public property, in which case pricing policies will be a central focus of the contract's design.
- **Provide PEV readiness educational and technical assistance** to employers and property owners of multi-unit dwellings (MUDs). These site hosts will seek information on how alternative pricing policies will affect the financial sustainability of their charge stations under differing conditions.
- **Verify** that city PEV readiness efforts are working. Many of the actions that planners can undertake—related to permit streamlining, zoning, parking regulation, and building

codes—are intended to drive down the soft and hard costs of installing charge stations and shift the costs to PEV drivers and building developers. Planners can only verify that these actions are working if they are aware of the factors that influence a site host's selection of pricing policies.

In addition to the reasons described above, planners' understanding of how to price charging strategically—in a way that reflects the costs of supplying charging as well as actual demand — can lead to better choices of charging locations. In an effort to spur growth in the number of charge stations, government programs have heavily subsidized the equipment and installation costs of these stations. In addition, regional deployment programs (initiated by the U.S. Department of Energy and state lawsuits) have resulted in quantity-based and time-limited deployment requirements. These deployment requirements have encouraged program implementers to install "convenience" site stations, locating them wherever an accepting site host can be conveniently found. As a result, these charge stations are unlikely to be located where either PEV demand is highest or construction and operation costs are lowest. This has resulted in underused stations that have been publicly subsidized, and which the site host will eventually have to pay to have removed.

This chapter provides planners with a primer on charge station pricing policies. Section 9.2 describes the roles and benefits of well-designed pricing policies to different stakeholders in the PEV ecosystem. Section 9.3 presents the major types of pricing policies that have been proposed or implemented. Section 9.4 presents a set of criteria for evaluating pricing policies while Section 9.5 describes how specific pricing policies impact PEV drivers differently depending upon their driving behavior and PEV type. The role of pricing policies in the financial viability of specific charging location types is discussed in the separate chapters on PEV planning for MUDs (Chapter 6), workplace charging (Chapter 7) and retail charging (Chapter 8).

9.2 The benefits of well-designed pricing policies

Well-designed pricing policies can benefit the major participants in emerging markets for charge stations. A central benefit to the site host or charge station operator (e.g., EVSP) of pricing is that it **generates revenue**. Some site hosts will set prices only to recover their costs. Some may seek to recover only operating costs, if their initial installed costs were subsidized, or if they have the altruistic goal of encouraging PEV adoption. Others may seek to recover all upfront and on-going costs. Those site hosts with a more entrepreneurial bent, especially network service providers, will go beyond the goal of cost recovery to set prices they hope will yield profits.

A second benefit of pricing is that it can **shift the costs of supplying the charging equipment onto those who benefit** from the using that equipment. This property of pricing can be especially helpful in workplaces and multi-unit dwellings. Employers and property owners may face legal, administrative, or ethical prohibitions on covering the cost of providing charge services to PEV drivers but not conventional fuel drivers.

A third benefit of pricing accrues to the PEV drivers when pricing encourages **the efficient use of charging equipment.** The social goal here is to enable those PEV drivers, who need and value charging most, to access charging equipment. Pricing can be used to efficiently allocate both charge station parking access and, in the case of multiplex charge stations, the charging capacity of the station. This is important, because as the PEV market grows, it will become increasingly important to ensure that charge stations are priced to encourage active charging and discourage overstays (connected or not to the charge station) so that stations are available for charging as much as possible. This can be done by increasing the costs of charge station parking (relative to nearby parking opportunities) when vehicles are not actively charging. Alternatively, the advent of smart chargers not only enables multiple PEVs to charge at one station, but these chargers also enable PEV drivers to select the combination of price-service priority for which each is willing to pay, given the available capacity. Drivers who are willing to pay a premium for quicker charging will be able to do so, while those who have more time or need less power can charge at a lower rate and price.

Finally, market prices that are set in response to real supply costs and consumer demand provide **valuable information to potential site hosts and PEV drivers**. They enable prospective site hosts to evaluate whether local PEV demand will generate the revenues needed to make new investments in charge stations financially sustainable. They also enable prospective PEV drivers to determine what the charging costs are at different locations and how that will, in turn, affect their expected PEV refueling costs.

The benefits to different stakeholders of well-designed PEV charging price policies are summarized in Table 9.1.

Table 9.1: Stakeholder benefits of strategically-priced PEV charging

Benefit	Stakeholders
Revenue generation	Station operators
Shift costs to beneficiary (driver)	Commercial property owners, employers, multi-unit dwelling owners
Efficient use of charging equipment	Waiting PEV drivers and station operators
Information on demand and market prices	Prospective site hosts, current and prospective PEV drivers
Transparency and fairness	PEV drivers

9.3 Types of pricing policies

Several pricing policies have been implemented or proposed, with some tailored or targeted to specific types of charging locations.

9.3.1 Monthly flat fees

A common pricing policy is a **flat fee** per month for access to a single charge station or network of charge stations. PEV drivers are able to access and charge as much as they wish during the subscribed time period. Commonly considered monthly flat fees have ranged from $25 to $75 for workplace charging. A version of this flat fee structure is the monthly **network subscription fee** which enables drivers to charge at any of the stations within the network. For example NRG currently offers a network subscription at the cost of $89 per month for its network which may include both residential and nonresidential Level 2 as well as public fast charging.

9.3.2 Hourly rates

There are two important versions of hourly rate policies. The first version is a **simple per-hour rate** for the time the PEV is actively charging. For Level 1 and 2 charge stations, observed per-hour rates range from $.50 up to $2.00 per hour. The second version is a **fixed connection fee** in combination with the per-hour rate. Fixed fees can also range from $.50 to as high as $3.00 per charge session.

There is a variation on the fixed-fee in combination with the hourly charge which is the **minimum fee** per connection event. This fee can be levied in two very different ways. First, this fee could levied so that once the total charge exceeds the minimum fee, the pricing policy becomes equivalent to a simple per hour charge. In the event that the driver does not exceed the minimum fee amount, this pricing policy functions like a flat connection fee per charge session. We will call this type an **offsetting minimum fee** structure since the per-hour charge offsets the minimum fee. Alternatively, minimum fees could also be levied as a connection fee which is added to the per hour total, which will then have the same properties as a fixed connection fee in combination with an hourly rate. We will call this an **additive minimum fee** structure. The driver must take care to understand how the total charges are calculated when minimum fees apply. [29]

9.3.3 Markup on costs

The last major type of pricing policy involves **markup on costs**. This policy takes the electricity cost (measured in cents per kilowatt-hour) plus any other ongoing variable costs, such as billing services, maintenance, or insurance costs, and then adds a percentage mark up on these variable costs. For public and non-profit organizations that simply want to cover their total costs, the mark-up portion of the price can be set to recover the upfront installation and equipment costs (or associated on-going financial costs). For profit-oriented station operators

29 As an example of an *offsetting* minimum fee, consider a station with a $1 minimum fee and $1 per hour policy. If the driver stops charging prior to the end of the first hour she pays $1. After the first hour of charging , she has exceeded the $1 the minimum fee, so only the hourly rate is used to calculate her total costs. In contrast, when an *additive* minimum fee applies, it is applied *in addition* to whatever the total hourly charge is. For example, once she had completed an hour of charging, her total costs would have been calculated by adding $1 for the hour of charging plus the $1 minimum fee for a total of $2.

the mark-up can be set strategically by time of day or location to maximize profits (in addition to covering costs).

9.3.4 Combination rates

Finally, network operators may employ a combination of pricing schemes at the same time. One version of this allows drivers within the network to pay different flat rate subscription fees each month in return for either access to different charge station services or differentiated hourly or kilowatt-hour prices. Another version differentiates in network and out of network customers, typically charging out of network customers higher fees.

9.4 Evaluative criteria

Charge station or network operators will look for pricing policies with four properties. The pricing policy should be:

- **Easy to calculate** and set
- **Easy to adjust** periodically as costs and market conditions change
- As **cost-effective** as possible by requiring minimum upfront and ongoing costs. Some pricing policies require that charge station operators have metering technologies and network systems that track the hours of usage or the amount of power consumed. When drivers pay with credit cards there are additional processing and billing charges that must be recovered.

The next two properties of pricing policies may be embraced by public and non-profit station operators but eschewed by profit-oriented operators. Pricing policies should be:

- **Transparent**, enabling drivers to quickly understand the unit and total costs they are likely to incur as a result of charge station use
- **Fair**, charging a common unit cost for all PEV drivers

Profit-oriented charging hosts will have incentives to select pricing policies in order to **maximize revenues** without regard to transparency and fairness. We can anticipate the profit-oriented operators will try to strategically obscure real costs from PEV drivers in order to increase revenues and profits. They may also seek to maximize revenues by charging different unit prices based on how much electricity is consumed or charge different unit prices to different customer classes.

9.5 Why pricing policies mean different things to different PEV drivers

PEV drivers may differ in several ways that differentiate the impacts of the public pricing policies. First, the amount of energy they consume at public stations will vary with the number

of electric miles they drive each day to that station. We know from travel diary data (Krumm 2012) that a relatively large percentage of drivers who travel in U.S. metropolitan areas travel only 10, 20 or 30 miles daily. Table 9.2 shows how different daily mileages translate into differing monthly and annual electric mileages (e-miles) and energy consumption.

Table 9.2: Differences in electric travel and charging needs

Assumptions	10 e-miles daily	20 e-miles daily	30 e-miles daily
10-year electric miles	36,500	73,000	109,500
Charger utilization (hours)	0.9	1.8	2.7
Daily kWh purchased	3.5	7	10.5

The cost per electric mile driven is calculated by dividing number of daily electric miles driven by the cost of refueling. The cost of refueling will vary between charging locations. The following sections illustrate how different pricing models result in different costs to drivers.

For these analyses, we assume that PEVs driving in electric mode are depleting their batteries at a rate of 34.82 kW/100 miles. This represents a weighted average fuel consumption based on the market share of individual PEV models.[30] When comparing this fuel consumption to a conventional vehicle (CV), our analyses assume a price of gasoline of $4.00, slightly above the average price of gasoline in California in 2012.[31] Electricity costs are assumed to be $0.195/kWh.

9.5.1 Monthly flat fees

When a pricing policy has a fixed-fee component, such as a connection fee per session or a monthly flat rate, and does not vary with the number of miles driven, then that policy will result in a per-mile cost that changes with the number of miles driven. The flat monthly fees illustrate this effect most simply. We describe in Table 9.3 what the $25, $50, and $75 flat monthly fee means for PEV owners who drive 10, 20 and 30 electric miles daily, respectively. When the $25 monthly flat rate is divided into the monthly mileage for 10, 20 and 30 electric daily miles, the cost per mile driven is almost three times higher ($2.17 per gallon equivalent) for the lowest mileage driver (10 e-miles) compared to the higher mileage driver (30 e-miles) who pays only $0.72 per gallon equivalent. At $75 dollars per month, this same calculation reveals that the lowest mileage driver pays $6.51 per gallon equivalent while the higher mileage driver pays only $2.17 per gallon equivalent. While all drivers pay the same flat monthly fee, what this analysis shows is that the effective cost per mile driven differs with the electric miles that are driven daily. In effect, this pricing policy discriminates across PEV drivers based on how much electricity

30 Source: HybridCars.com (accessed 7/15/2012)

31 U.S. Department of Energy – Energy Information Administration. Accessed 7/23/2012: http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPM0_PTE_SCA_DPG&f=W

each consumes, which varies with their driving behavior, vehicle characteristics, and access to charging.

Table 9.3: Monthly flat fees and cost equivalents to drivers

Fee levels	10 e-miles daily		20 e-miles daily		30 e-miles daily	
	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent
$25- Flat monthly fee	$0.07	$2.17	$0.04	$1.09	$0.02	$0.72
$50 - Flat monthly fee	$0.14	$4.34	$0.07	$2.17	$0.05	$1.45
$70 - Flat monthly fee	$0.22	$6.51	$0.11	$3.26	$0.07	$2.17

9.5.2 Hourly rates

In Table 9.4, we evaluate the impacts of commonly encountered hourly rates on unit driving costs. Unit costs do not differ across drivers who travel differing numbers of daily electric miles, as long as the fee assessed stops when charging stops. At $1.00 per hour, current PEV drivers will pay $2.40 per gallon equivalent while at $2 per hour, this price jumps to approximately $4.78 per gallon equivalent. However, this analysis of hourly rates is based on the assumption that current PEVs have 3.3 kW chargers on board.

At the top of Table 9.4, we show how the addition of a $1.00 connection fee affects the costs per mile and gallon equivalent when drivers differ in the daily electric mileage. A $1.00 connection fee added to a $1.00 hourly rate represents $5.05 per gallon equivalent for low mileage PEV drivers (10-miles daily) and $3.28 for higher mileage PEV drivers (30-miles daily). Although both drivers pay the same $1.00 connection fee, when expressed as unit costs, it represents a 53% increase in the cost per electric mile driven for the low-mileage driver compared to the higher-mileage driver. Table 9.4 also shows how a $1.00 connection fee plus a $2.00 hourly rate impacts drivers with differing daily electric miles; we will compare this to the cost of residential charging shortly.

An increasing number of PEV models are being released that have 6.6-kilowatt chargers on board. The bottom of Table 9.4 shows how the unit costs for these hourly rates will differ across the two types of onboard chargers. Because the charge rate per hour doubles, the cost per hour is cut in half for models with 6.6 kW chargers on board. Thus, an hourly rate pricing policy will result in much cheaper unit fuel costs for newer PEVs and higher unit fuel costs for the 60,000 lower-power PEVs that have been sold in the U.S. to date.

Table 9.4: Hourly rates, hourly rates with connection fees and cost equivalents to drivers

Fee levels	10 e-miles daily		20 e-miles daily		30 e-miles daily	
	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent
Hourly fee - $1	$0.08	$2.40	$0.08	$2.39	$0.08	$2.40
Hourly fee - $1 + connection fee - $1	$0.17	$5.05	$0.12	$3.71	$0.11	$3.28
Hourly fee - $2	$0.16	$4.81	$0.16	$4.78	$0.16	$4.79
Hourly fee - $2 + connection fee - $1	$0.25	$7.45	$0.20	$6.10	$0.19	$5.67
Hourly fee - $1 (6.6 kW)	$0.04	$1.20	$0.04	$1.20	$0.04	$1.20
Hourly fee - $2 (6.6 kW)	$0.08	$2.41	$0.08	$2.39	$0.08	$2.40

9.5.3 Markup on costs

Thus far, all three major types of pricing policies discriminate against PEV drivers who differ in either their number of daily miles driven or the vintage of the PEV. Next, we evaluate the variable costs plus a markup pricing policy. Table 9.5 shows that, for a given charging station power level, this policy would not affect drivers differently. All drivers face the same average costs regardless of how many miles they drive or the vintage of their PEV.

Table 9.5: Markups on variable costs and cost equivalents to drivers

Markup levels	10 e-miles daily		20 e-miles daily		30 e-miles daily	
	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent	$/Electric Mile	$/Gallon Equivalent
Electricity + $0.10 Markup	$0.09	$2.72	$0.09	$2.72	$0.09	$2.72
Electricity + $0.15 Markup	$0.11	$3.18	$0.11	$3.18	$0.11	$3.18
Electricity + $0.20 Markup	$0.12	$3.64	$0.12	$3.64	$0.12	$3.64

9.5.4 The costs of alternatives to workplace, commercial retail, and MUD charging

PEV drivers are likely to develop their daily refueling plan based on their expectations about

the costs of non-residential charging (e.g., workplace and commercial retail) versus the costs of residential electric and gasoline refueling (in the case of PHEV owners). The cost of refueling residentially will depend upon both the level of charging service needed, the installed costs of the charger (if Level 2 is needed), and the ongoing cost of the electricity. Table 9.6 presents the unit cost for Level 1. For the sake of comparison, we also present the cost of refueling with gasoline at $3.50, $4.00, and $4.50 per gallon. The unit costs do not vary with the number of electric miles driven.

Table 9.6: Benchmarks for residential Level 1 charging and gasoline costs

Comparison Cost Levels	$/Electric Mile	$/Gallon Equivalent
Level 1 electricity cost only	$0.06	$1.80
$3.50 gas	$0.12	$3.50
$4.00 gas	$0.14	$4.00
$4.50 gas	$0.15	$4.50

One reason planners may observe low levels of utilization of workplace and retail charging equipment is that pricing policies in these locations often result in much higher unit costs of charging than does residential charging or even refueling with gasoline. We discuss the price/cost interactions between residential, workplace and commercial retail charging in Chapter 5, Chapter 6, Chapter 7 and Chapter 8.

9.6 Choosing pricing policies for different charge environments

Site hosts in different charging environments may favor aspects of particular pricing policies. For example, station operators in retail environments may prefer an hourly rate with connection fees because they maximize revenues from PEV drivers with relatively short parking times. PEV drivers that stay only a short period of time still pay the fixed fee, which generates most of the revenues for the station operator. Of course, many PEV drivers recognize that these pricing policies represent extremely high unit prices and choose to refuel elsewhere.

At both workplaces and MUDs, station operators face important tradeoffs when selecting pricing policies. On one hand, station operators in these environments would ideally be able to change the price of charging over the course of a day in order to encourage charging when it is most cost-effective for the driver, site host, and utility.[32] However, those pricing policies that allow for time-of-day pricing also require the added cost to the operator of measuring

32 Some MUDs and workplaces may be advised to use non-pricing policies to regulate usage. For example, some site hosts will find it beneficial to discontinue charging services during peak periods of the day in order to avoid demand charges and reduce electricity costs.

and billing according to the time elapsed or energy consumed (either by the hour or kilowatt-hour). This would be true for both the electricity markup policy and the hourly rate policy. Flat rates, in contrast, avoid these measurement and billing costs to employers but have the disadvantage of imposing different unit costs (e.g., cost per electric mile driven) on PEV drivers who travel different numbers of electric daily. For large MUD owners and employers, the long-term revenue and efficiency benefits of being able to use time-of-day pricing on use of charging equipment is likely to outweigh the operational costs.

9.7 References

HybridCars.com. 2012. http://www.hybridcars.com/.

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U.S. Department of Energy, Energy Information Administration. 2012. Weekly California All Grades All Formulations Retail Gasoline Prices. http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPM0_PTE_SCA_DPG&f=W.

13 Parking Guidelines for PEV Readiness

13.1 Introduction

As with any vehicle, electric vehicles will be parked most of the time, whether or not they are plugged in or actively drawing power from a charging source. But unlike conventional vehicles, PEV fueling opportunities are possible almost everywhere within the parking environment: in residential garages, at curbsides, and in both workplace and retail parking lots.

Given the interest by local governments in policies that encourage PEV adoption, parking policies and guidelines will underlie every aspect of PEV planning. Such policies can assist with cost recovery, accessibility to disabled drivers, facilitating turnover at charging stations, and making stations more visible and easy to locate. In particular, clear and visible messaging on PEV directional and regulatory signs can raise the profile of PEVs and signal the advantages of these vehicles to the public (California Plug-in Electric Vehicle Collaborative 2012)

PEV parking policies and guidelines cover a wide range of issues, including:

- Location and number of charging spaces
- Design of PEV charging spaces in compliance with the Americans with Disabilities Act (ADA)
- Managing access to PEV parking
- Whether and how to price parking for PEVs
- Design of PEV signage in compliance with federal and state standards

There are currently no regional or state ordinances that standardize implementation of these PEV readiness measures. Local jurisdictions have leeway in determining signage on surface streets, providing for a certain number of PEV-ready parking spaces, and ensuring disabled access in new and existing construction. However, only 14% of agencies and utilities surveyed by the California Plug-in Electric Vehicle Collaborative have established specific zoning and parking ordinances for EVSE installations (California Plug-in Electric Vehicle Collaborative 2012). Consistent installation and signage standards across jurisdictions will lay the groundwork for

future state or regional ordinances, facilitate PEV readiness by eliminating the burden of local regulation development, and clearly communicate to the public how PEV infrastructure should be used.

The California Plug-in Electric Vehicle Collaborative has incorporated PEV charging stall design and signage guidelines from a variety of sources into a set of uniform accessibility and signage standards (California Plug-in Electric Vehicle Collaborative 2012). The standards recommended by the California PEV Collaborative comply with the ADA and California Building Code and will be presented later in this chapter.

What follows are considerations that should be kept in mind when designing and regulating PEV parking and/or charging spaces.

13.2 Location and number of charging spaces

Before deciding whether and where to mandate PEV parking, cities should understand what their likely demand for PEVs will be and whether charging demand can best be satisfied by residential, workplace or publicly accessible charging. The Southern California Regional PEV Readiness Plan will include maps for the region's nearly 200 cities that will reveal projected demand for PEVs as well as multi-family, workplace, and retail charging opportunities.

The Bay Area Climate Collaborative's *Ready, Set, Charge, California!* identifies a number of parking area features that should be considered when placing charging units, including:

- The source of electricity and electrical panels/circuits
- Whether there is enough electrical power capacity beyond existing loads
- Whether to make lighting, shelter, signage and pedestrian improvements with charging units
- The location of existing disabled-accessible parking spaces and the location of accessible charging units
- Whether cables will infringe on walkways or high pedestrian-traffic areas

13.3 Designing ADA-compliant PEV charging spaces

Interpretation of disabled access requirements for electric vehicle charging stations is evolving. Local jurisdictions have some discretion in how they interpret PEV charging accessibility requirements. California's green building code (CALGreen) provides voluntary measures for cities to adopt if they wish to require a minimum number of charger-ready spaces in new construction. CALGreen does not stipulate how many of those spaces must be disabled-accessible.

Reflecting the historical separation of parking and fueling into different land uses, the California

Building Code provides one set of standards for disabled parking accessibility and another for disabled fueling accessibility, including for electricity (California Plug-in Electric Vehicle Collaborative 2012). Some cities may wish to encourage PEV adoption by providing preferential parking spaces for PEVs, with or without charging equipment. When **no** charging equipment is provided, parking spaces designated for PEVs need only follow the standards for disabled parking stall allocation and design as described in the Americans with Disabilities Act, California Building Code and local ordinances. When **both** parking and charging are provided, accessibility standards for both must be applied. However, the two standards may conflict, as PEV charging cords may impede the disabled-accessible path of travel to a building. In such cases, charging equipment should not be provided in a space intended for disabled-accessible PEV parking (California Plug-in Electric Vehicle Collaborative 2012).[41]

To date, the only official state guidance on accessibility requirements for PEV charging spaces is a set of interim guidelines developed by the Division of the State Architect in 1997. The California PEV Collaborative developed its own set of guidelines in 2012 that distinguish between curbside and offstreet parking, and public and restricted access. Yet another set of guidelines is available in *Ready, Set, Charge, California!* Section 3.5.2.

The Division of the State Architect and California PEV Collaborative guidelines are provided below. Local jurisdictions should consider which guidelines (if any) may be appropriate for them to codify, as doing so may provide additional clarity on enforcement matters.

13.3.1 Division of the State Architect Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations

This set of guidelines was developed in 1997 to govern accessibility to charging stations on state-funded properties. However, local jurisdictions can adopt similar guidelines for code enforcement. While these state guidelines identify PEV charging as a public accommodation, local jurisdictions must determine whether they want to apply the guidelines to multi-unit dwellings.

The goal of ensuring disabled access to PEV charging may be complicated by the cost considerations involved in retrofits or the need to give up adjoining spaces to provide an accessible path of travel. There is an exception in these guidelines for providing the accessible path of travel to restrooms and other facilities from the charger if the cost of doing so exceeds 20% of the cost of charger installation. Note that under these guidelines, charging spaces should be *accessible* to those with disabilities, but need not be reserved *exclusively* for use by persons with disabilities.

The following questions and answers are excerpted from the Division of the State Architect's Access Compliance Policies:

41 In other words, the PEV parking space could be situated as close as possible to the building entrance to accommodate a disabled PEV driver, but he or she may have to charge elsewhere. A potential solution involves overhead supports from which charging cords can hang above the vehicle (eTec 2010).

Are EV charging stations required to be accessible?

Yes. EV Charging Stations are required to be accessible because they offer a service to the general public. When EV charging is coupled with regular parking, the EV charging is considered the primary service.

What percentage of the EV charging stations must be made accessible?

The following table shall be used in determining the required number of accessible charging stations:

Number of charging stations provided at a site	Number of accessible charging stations required
1 - 25	1
50	2
51-75	3
76-100	4

What specifications must the accessible EV charging station comply with?

a. A 9 foot wide space by 18 feet deep space is required. An access aisle of 5 feet on the passenger side is required. One in every eight accessible charging stations, but not less than one, shall be van accessible with a 8 foot access aisle.

b. The accessible EV charging station and its access aisle need not be striped or provided with signage as required for an accessible parking space. An information sign must be posted which reads, "Parking for EV Charging Only; This Space Designed for Disabled Access; Use Last."

Must accessible EV charging stations be reserved exclusively for the use of persons with disabilities?

No. The primary function of these stations is the charging of Electric Vehicles. Parking is not intended to be the primary use of the charging station.

Are there any restrictions relative to the location of accessible EV charging stations?

For installations associated with new construction, the accessible charging station must be located in close proximity to a major facility, public way or a major path of travel on the site. Note: 200 feet is the maximum distance recommended. However, the charging stations need not be provided immediately adjacent to the major facilities since, again, the primary purpose of the stations is to provide the charging as a service, and parking is not intended to be the primary use of the stations.

For installations at existing sites, the accessible charging station need not be located in close proximity to other services at the site.

Is an accessible path of travel required from the accessible EV charging station to other services provided at the site?

Yes, for installations associated with new construction. As for other facilities on the site, an accessible path of travel is required between facilities.

For installation at an existing site, an accessible path of travel is required to the extent that the cost of providing such path does not exceed 20% of the cost of the EV equipment and installation of all EV charging stations at the site, when such valuation does not exceed the threshold amount referenced in Exception 1 of Section 1134 of Title 24. The accessible path of travel shall connect to a major facility, public way or major path of travel on the site.

What specifications must the charging equipment meet?

The charging equipment must meet all applicable reach range provisions of Section 1118B of Title 24. A clear path of travel measuring 36 inches in clear width to the charging equipment is required.

Does the installation of charging stations at an existing site trigger path of travel improvements such as primary entrance to other facilities, restrooms, telephones, or drinking fountains?

No, unless the above features are located in the parking lot, are accessed directly from the parking lot and designed for use with the parking lot.

How does the three-year valuation accumulation apply to these installations?

The valuation of other improvements at the site over the last three years need not be added to the cost of the installation to determine application of the exception referenced in item VI above. The cost of installation of other EV charging stations at the site over a three-year period must be used in determining compliance with the exception.

13.3.2 California PEV Collaborative Accessibility Guidelines

The California PEV Collaborative provides guidelines on disabled accessibility and sample drawings for public- and restricted-access *charging* spaces in both new construction and existing facilities. These guidelines, summarized in Figure 13.1 and Table 13.2 below, also include standards for card readers at charging stations, which also must be disabled-accessible per the California Building Code (California Building Standards Commission).

Table 13.1: California PEV Collaborative ADA-Compliant EVSE Installation Guidelines for New Construction

	Public		Restricted
	Curbside	Offstreet	
EVSE location	Last space on the block before intersection, in direction of travel	ADA spaces (if not obstructing travel path)	Fleets and designated uses: conform to standards for public charging, unless no fleet vehicles or designated uses require disabled access Residential: if required, conform to standards for new public charging
Vehicle orientation	Diagonal or perpendicular to curb	Diagonal or perpendicular to EVSE	
Accessible aisle to EVSE	3' - 8' wide, left of charging space	9' for vehicle, 3' on either side of charging space (total 12')	
Van access aisle to EVSE	N/A	9' for vehicle, 8' on either side of charging space (total 17')	
Sidewalk pedestrian clearance	4' unobstructed between EVSE and building wall or other obstruction	N/A	
EVSE clearance	24" from curb	N/A	
EVSE area	N/A	Within 9" of center of a level 30" x 48" area, long side parallel to controls, no more than 2% slope in any direction	
EVSE height	N/A	Operable part no more than 48" above surface of EVSE area	
EVSE protection	Bollards or equivalent	Bollards or equivalent	
Cord management	Retractable cord preferred	Retractable cord preferred	
Lighting and signs	Adequate to minimize hazards; signs include use restrictions and contact information to report problems	Adequate to minimize hazards; signs include use restrictions and contact information to report problems	
Number of ADA charging spaces or card readers	No recommended minimum	First of every 25 stations; first of every 6 ADA charging spaces should be van-accessible; first tow card readers should be ADA accessible	

Table 13.2: California PEV Collaborative Accessible EVSE Installation Guidelines for Existing Facilities

	Public		Restricted	Card Readers
	Curbside	Offstreet		
EVSE location	Last space on the block before intersection, in direction of travel	ADA spaces, if feasible		
Vehicle orientation	Orientation of existing curbside parking; diagonal or perpendicular preferred	Diagonal, perpendicular or parallel		
Accessible aisle to EVSE or card reader	3' wide at left, front or rear of charging space	9' for vehicle, 3' on either side of charging space (total 12')		3' wide from EVSE to card reader, unless co-located
Van access aisle to EVSE	N/A	9' for vehicle, 8' on either side of charging space (total 17')		
Sidewalk pedestrian clearance	4' unobstructed between EVSE and building wall or other obstruction	N/A		
EVSE or card reader clearance	24" from curb	N/A	Fleets and designated uses: conform to standards for public charging, unless no fleet vehicles or designated uses require disabled access Residential: if required, conform to standards for new public charging	Centerline of card reader should be 24" (+/- 9") to nearest obstruction, excluding EVSE and cords
EVSE or card reader area	N/A	Within 9" of center of a level 30" x 48" area, long side parallel to controls, no more than 2% slope in any direction		Within 9" of center of a level 30" x 48" area, long side parallel to controls, no more than 2% slope in any direction
EVSE or card reader height	N/A	Operable part no more than 48" above surface of EVSE area		No more than 54" above accessible EVSE or card reader surface
EVSE protection	Bollards or equivalent, if vehicle is diagonal or perpendicular to curb; advised but not required for parallel orientation	Bollards or equivalent		
Cord management	Retractable cord preferred	Retractable cord preferred		
Lighting and signs	Adequate to minimize hazards; signs include use restrictions and contact information to report problems	Adequate to minimize hazards; signs include use restrictions and contact information to report problems		
Number of ADA charging spaces or card readers	No recommended minimum	First of every 25 stations; first of every 6 ADA charging spaces should be van-accessible; first tow card readers should be ADA accessible		First 2 card readers should be accessible

13.4 Managing access to charging spaces

In addition to determining standards for PEV charging space design, local jurisdictions can designate spaces that are only for PEV charging and/or parking. Spaces designated for this purpose, along with the appropriate signage, will discourage non-PEV drivers from using these spaces and support their availability for PEV drivers. The California Vehicle Code prohibits any vehicle from parking in a space intended for PEV charging unless it is connected to EVSE, but the law does not specify whether the vehicle must be actively drawing power (2012 California Vehicle Code, Section 22511.1). The law also authorizes local authorities and private parking facility owners to tow vehicles in charging spaces that are not connected to EVSE, as long as proper signage is in place to warn drivers (2012 California Vehicle Code, Section 22511).

The following is an example of a local ordinance on designating PEV-only spaces:

13.4.1 Santa Monica (2012)

The Director of Planning and Community Development, or his or her designee, is authorized to designate parking spaces or stalls in an off-street parking facility owned and operated by the City of Santa Monica or the Parking Authority of the City of Santa Monica for the exclusive purpose of charging and parking a vehicle that is connected for electric charging purposes. (Santa Monica Municipal Code, Ordinance 2403, Section 29 2012)

13.5 Pricing PEV parking

Local governments and private property owners should also consider how much drivers should pay for charging and/or PEV parking. Such decisions should balance cost recovery considerations with the need to both incentivize PEV use and possibly discourage drivers from leaving their PEVs parked in charging spaces after they have refueled.

The pricing decision involves some combination of free or priced parking and free or priced charging. For example, site owners can provide free parking for PEVs but require payment for using the charging equipment. Alternatively, they can require payment for parking and offer charging for free. Yet another strategy would involve requiring payment for both PEV parking and charging, or offering both for free. Detailed guidance on cost recovery scenarios, both break-even and for-profit, are presented in Chapter 9. Pricing guidance for charging in multi-unit dwellings (Chapter 6), workplaces (Chapter 7) and retail (Chapter 8) is available elsewhere in this document.

Cities may want to initially encourage PEV use by offering free or discounted parking while PEVs are charging, and then begin charging full price for parking after the vehicle has fueled. This would encourage drivers to move their cars and allow other PEV drivers to use the charging space, but would not penalize drivers who do not move their cars in a timely fashion. As PEVs become more ubiquitous and demand grows for charging spaces, cities should consider

additional measures, such as reasonable time limits on public charging spaces (Peterson 2010).

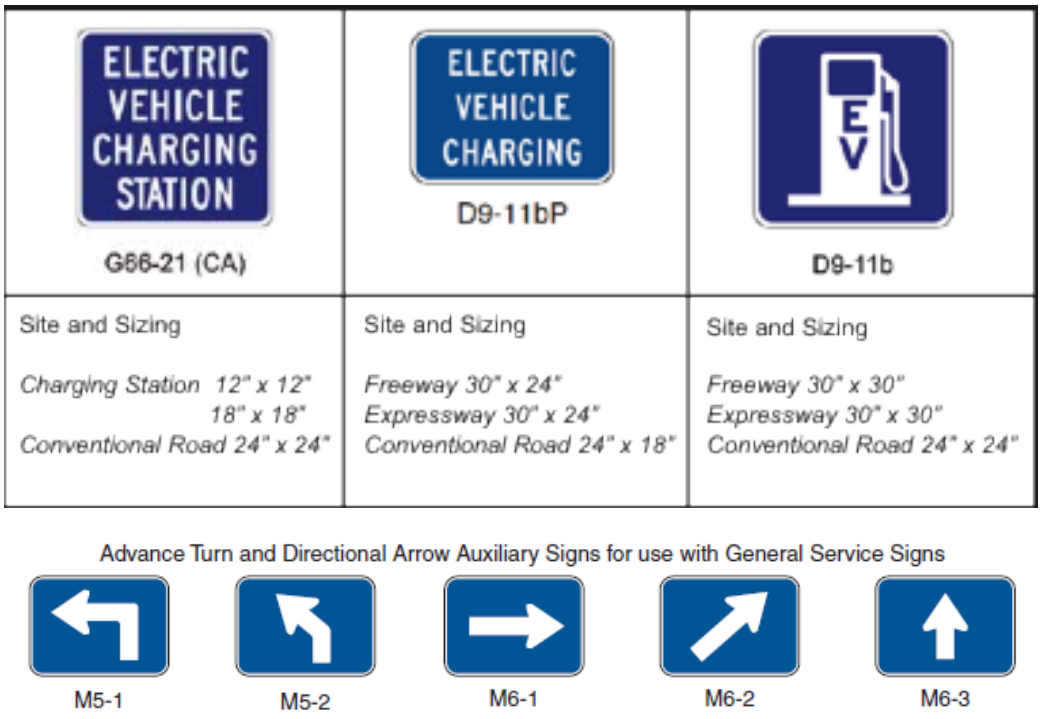
13.6 Signage

Signs are needed to direct drivers to PEV charging stations and enforce time limits or PEV-only access to certain spaces. Although traffic control signs must follow state and federal guidelines, local jurisdictions have an important role to play in placing signs on local streets and public parking facilities. Local governments must back up enforcement language on signs with ordinances and penalties for violation. Clear, consistent signage across jurisdictions can also encourage PEV adoption by minimizing driver confusion.

Traffic control signs are standardized according to the California Manual on Uniform Traffic Control Devices. The manual incorporates federal standards as well as California-specific alternative signs approved by the Federal Highway Administration (California Plug-in Electric Vehicle Collaborative 2012).

In its review of PEV signage, the California PEV Collaborative identifies two types of signs: general service signs and regulatory signs. General service signs indicate the presence of a charging station and/or provide directional arrows. The general service signs in Figure 13.1 below are approved for use in California.

Figure 13.1: Approved General Service Signs for PEV Charging



Source: California PEV Collaborative, Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure (2012)

The Federal Highway Administration (FWHA) has granted interim approval to the states of Oregon and Washington to use yet another sign, shown in Figure 13.2. Other jurisdictions may use this sign if they request authorization to do so from FHWA, until this sign is incorporated into standard federal guidelines.

Figure 13.2: PEV Charging Sign with Interim Federal Approval

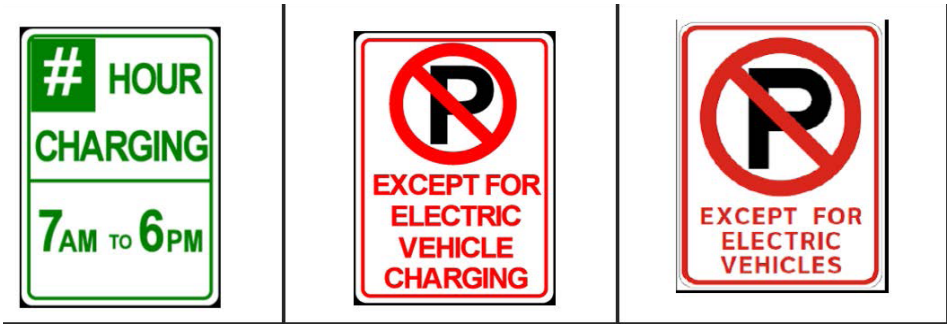
Source: California PEV Collaborative, Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure (2012)

In addition to general service signs, the California PEV Collaborative identifies another type of sign that enforces restrictions on parking and/or charging access for PEVs. So-called regulatory signs "permit or restrict the use of a charging station, similar to signs that prohibit or limit time for parking." (California Plug-in Electric Vehicle Collaborative 2012)

The California MUTCD and the Federal Highway Administration have not approved any PEV regulatory signs. The California PEV Collaborative recommends that local governments request authorization to use regulatory signs currently approved for testing in Oregon and Washington, "with the expectation that they ultimately will be approved at the federal level and become the uniform standard nationally" (California Plug-in Electric Vehicle Collaborative 2012). The signs are shown in Figure 13.3. They represent non-monetary ways to limit charging or parking access. The first sign specifies a time limit on charging, but does not provide a way for drivers to charge longer if they are willing to pay to do so.

The signs should measure 12"x18" and be installed in accordance with the California MUTCD and California Building Code. (California Plug-in Electric Vehicle Collaborative 2012)

Figure 13.3: Candidate regulatory signs for PEV charging



Source: California PEV Collaborative, Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure (2012)

13.6.1 Other sign considerations

- General service and regulatory signs may be used in combination. Best practices indicate that additional signs provide instructions on how to use the charging equipment, a number to call to report problems, and a definition of what constitutes appropriate occupation of the space (California Plug-in Electric Vehicle Collaborative 2012).
- The California Vehicle Code authorizes local authorities and private parking facility owners to tow vehicles in charging spaces that are not connected to EVSE, as long as proper signage is in place to warn drivers (2012 California Vehicle Code, Section 22511). This signage must measure 17"x 22" with one-inch lettering that states, "Unauthorized vehicles not connected for electric charging purposes will be towed away at owner's expense." The sign must also include contact information for where the vehicle will be towed and the local law enforcement agency (2012 California Vehicle Code, Section 22511).

13.7 PEV parking in different environments

While near-term charging demand will come mostly from single-family homes, local jurisdictions and property owners can encourage PEV adoption in multi-unit dwellings, workplace, and retail settings. Doing so will require a variety of parking policies, signage, and cost recovery strategies that suit these different land uses.

Customers, tenants and employees depend on the availability of parking spaces to shop, live, and work. Parking spaces are also an important source of revenue for local governments and some private property owners. Determining how many spaces to allocate for PEV parking and/or charging in existing buildings involves tradeoffs between at least two different goals: preserving existing parking spaces and/or revenue, and investing in PEV charging as a new amenity, public service or revenue source. Site owners should assess their current and potential demand for PEV charging by surveying employees and tenants. Installing one charging unit can also help reveal true demand for the service. The economics of hosting a PEV charge station are discussed in further detail in Chapter 9.

13.8 Recommendations

The following recommendations are intended to facilitate PEV charging through parking policies and signage. These recommendations should be adapted to reflect local land use opportunities for PEV charging and anticipated PEV demand, which may vary greatly among cities. Guidance on assessing local land use opportunities is provided in Chapter 4, Chapter 5, Chapter 6, Chapter 7, and Chapter 8. Additional resources on zoning and parking policies are provided in Chapter 10 of this document. Local jurisdictions should consult the Southern California PEV Atlas that accompanies this document for local PEV demand projections and maps of employment and commercial density.

1. Codify guidelines for disabled access to PEV charging spaces.
2. Adopt policies that facilitate the placement of signage on public property by non-city charging site owners (e.g. on sidewalks or public streets).
3. If demand for charging exceeds available charging capacity, consider measures to facilitate turnover at PEV charging spaces. Measures can include one or more of the following:
    - Clarify California Vehicle Code to require that PEVs parked in a charging space be connected to an EVSE and actively drawing power.
    - Post signage with chargers that cites relevant California vehicle code in order to be able to enforce towing of vehicles if they are not PEVs, connected to EVSE, and/or actively drawing power.
    - Charge for parking if PEVs are still parked but not actively drawing power.
    - Impose time limits on charging to allow other PEVs to use limited charging spots.
4. Use a single general service sign (accompanied with standard directional signage) for PEV charging as shown in Figure 13.1 or as shown in Figure 13.2 with interim FHWA approval. Local governments can request approval to use the general service sign with interim federal approval until a national standard is available.

13.9 Additional resources

The California PEV Collaborative's *Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure* (2012) recommends a uniform set of accessibility standards that comply with the ADA and California Building Code, as well as signs that comply with federal and state guidelines, or that have been submitted for federal or state approval. http://www.pevcollaborative.org/sites/all/themes/pev/files/PEV_Accessibility_120827.pdf

The Bay Area Climate Collaborative's *Ready, Set, Charge, California!* A Guide to EV-Ready Communities (2011) provides sample code language for reserving public parking spaces for PEVs, as well as design and installation guidelines for both on- and off-street charging stations.

http://www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf

- Section 3.2.1 (Sample zoning code provisions)
- Section 3.3 (Vehicles and traffic)
- Section 3.4.1 (On-street electric vehicle charging stations)
- Section 3.4.2 (Off-street electric vehicle charging stations)
- Section 3.5.2 (ADA and reasonable accomodations)

- Section 3.6 (Signage)

13.10 References

2012 California Vehicle Code, Section 22511. http://www.dmv.ca.gov/pubs/vctop/d11/vc22511.htm.

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